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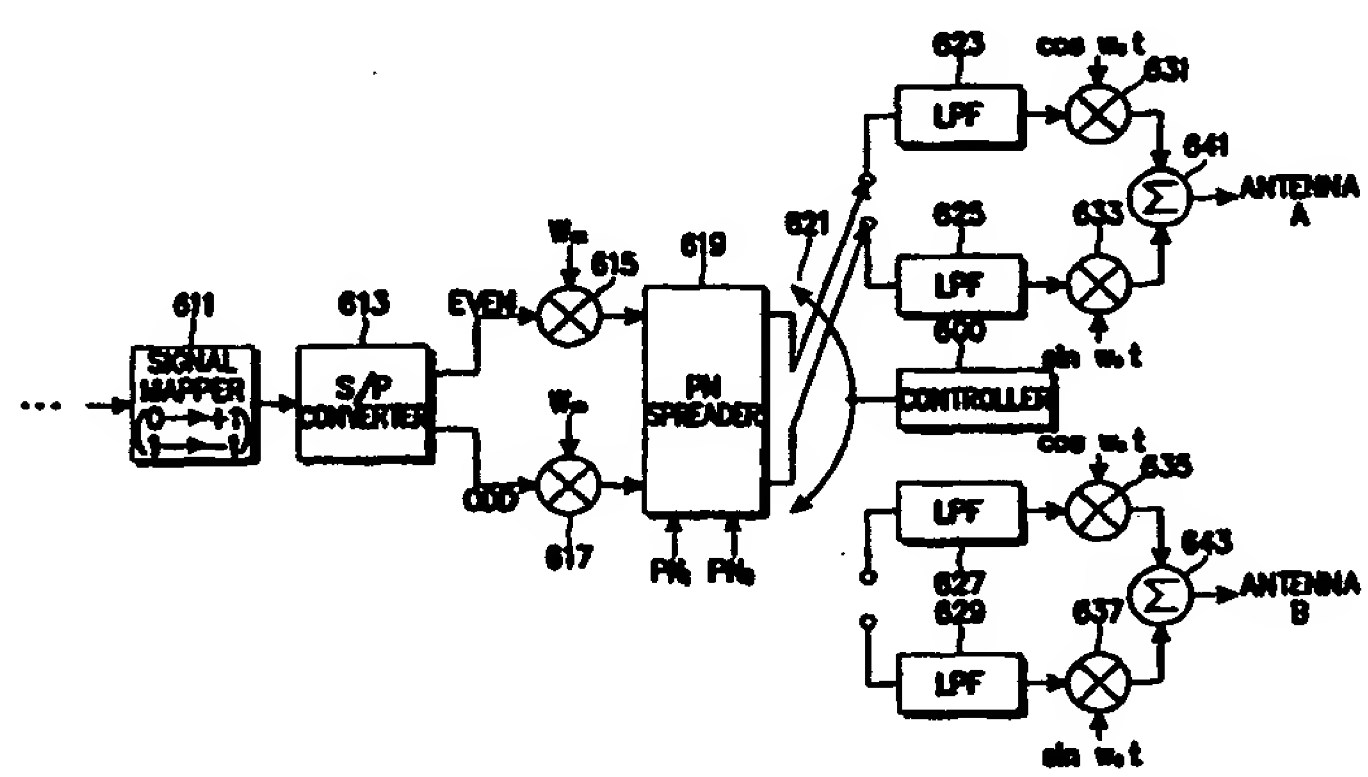

(57) Abstract

The transmitting device has a plurality of transmission antennas (A, B), RF (Radio Frequency) transmitters as many as the transmission antennas and connected to their corresponding transmission antennas, for outputting signals on a forward link, a controller (600) for generating a switch controlling signal in a non-overlapped time cycle, an orthogonal modulator (615, 617) for modulating a transmit signal by an orthogonal code, a spreader (619) for spreading the output of the orthogonal modulator, and a switch (621) connected to an output terminal of the spreader, for connecting the output of the spreader to a corresponding transmitter based on the switch controlling signal. According to another feature of the present invention, a receiving device in a mobile station of a mobile communication system has a pilot channel receiver for detecting a pilot channel signal from an input forward link signal and generating estimated phase and time values, a controller for generating a selection control signal based on cycle information and switching pattern information, in synchronization of a reference time to a base station, a selector for selectively outputting the estimated phase and time values received from the pilot channel receiver based on the selection control signal, and a traffic channel receiver for detecting a traffic channel signal at the selected estimated time position and correcting a phase error of the detected traffic channel signal based on the estimated phase value, for signal decoding.

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DEVICE AND METHOD FOR PROVIDING TIME SWITCHED TRANSMISSION DIVERSITY IN MOBILE COMMUNICATION SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a transmitting/receiving device and method with a diversity function, and in particular, to a device and method for transmitting/receiving data with a time switched transmission diversity (TSTD) function.

2. Description of the Related Art

Data transmission/reception performance can generally be increased by a diversity technique in a mobile communication system under a fading environment. FIG. 1 is a view illustrating diversity techniques applicable to forward and reverse links in a mobile communication system.

Referring to FIG. 1, data can be transmitted on a reverse link with receiver diversity. To do this, a base station is equipped with a plurality of reception antennas. For a forward link, there are three diversity techniques: transmission diversity, receiver diversity, and mixed diversity. In transmission diversity, a base station transmits a signal through a plurality of transmission antennas and a mobile station receives the signal through a single reception antenna with the effect that might be obtained with plural reception antennas. Receiver diversity is provided

when the mobile station has a plurality of reception antennas, and a mixed form of the transmission and reception diversity techniques is called a mixed diversity.

The reception diversity technique on the forward link, however, has the problem that diversity gain is small because the small size of a terminal limits the distance between reception antennas. Another problem is that use of plural reception antennas requires a separately procured hardware configuration for receiving a forward link signal and transmitting a reverse link signal through a corresponding antenna, thereby imposing constraints on the size and cost of the terminal. In view of these problems, the mobile communication system typically employs the transmission diversity technique on the forward link.

For the transmission diversity on a forward link, a base station and a mobile station in a mobile communication system have transmitting and receiving mechanisms, respectively, as shown in FIG. 2. In FIG. 2, a baseband signal processor 103 of a base station 100 converts user data for transmission on the forward link to a baseband signal. The process in the baseband signal processor 103 involves channel encoding, interleaving, orthogonal modulation, and PN (Pseudo Noise) spreading. A signal distributor 102 distributes a signal received from the baseband signal processor 103 to N transmission antennas TXA1 to TXAN. Hence, the transmission end of the base station 100 executes a transmission diversity through the N antennas.

A mobile station 200 has a single reception antenna RXA for receiving signals from the base station 100 through the N transmission antennas. To process the received signals, the terminal 200 includes N demodulators 201 to 20N corresponding to the N transmission antennas. A combiner 211 combines

demodulated signals received from the demodulators 201 to 20N, and a decoder & controller 213 decodes a signal received from the combiner 211 to produce decoded user data.

In FIG. 2, the user data to be transmitted from the base station 100 to the mobile station 200 is encoded in the baseband signal processor 103 and divided into N streams in the signal distributor 102, and transmitted through the corresponding transmission antennas TXA1 to TXAN. Then, the mobile station 200 demodulates the signals received through the single reception antenna RXA in the N demodulators 201 to 20N as many as the transmission antennas TXA1 to TXAN and combines the demodulated signals, thereby obtaining diversity gain.

Now, the structure of a transmitter in a non-transmission diversity (NTD) CDMA communication system will be described. Referring to FIG. 3, the NTD in a base station includes a CRC (Cyclic Redundancy Check) generator 311 for adding CRC bits to input user data in order to detect a frame error which occurs while sending the user data. A tail bit generator 313 adds tail bits indicating termination of a data frame to the data frame prior to channel encoding. Then, a channel encoder 315 encodes the data frame for error correction and an interleaver 317 interleaves the encoded data. A combiner 323 exclusive-ORs the interleaved data with a long code sequence. This long code sequence is generated in a long code generator 319 and decimated in a decimator 321 at the same rate as that at an output terminal of the interleaver 317. A signal mapper 325 converts 0s and 1s of the encoded data received from the combiner 323 to +1s and −1s respectively, for orthogonal modulation. A serial-to-parallel (S/P) converter 327 divides the signal received from the signal mapper 325 into I channel and Q channel streams, for QPSK (Quadrature Phase Shift Keying) modulation. The I channel and Q channel

streams are subject to orthogonal modulation in multipliers 329 and 331 and PN spreading in a PN spreader 333. The spread signal is filtered for pulse shaping in LPFs (Low Pass Filters) 335 and 337, loaded on a carrier, and finally transmitted through a transmission antenna.

The transmit signal output from the NTD transmitter in a base station shown in FIG. 3 has a structure indicated by 511 of FIG. 5. FIG. 5 illustrates timing characteristics of user data output from the NTD transmitter and from an orthogonal transmission diversity (OTD) transmitter with two antennas (N=2). An OTD transmitter was exploited as shown in FIG. 4 to improve the performance of a forward link channel in an NTD CDMA mobile communication system. In the OTD transmitter, information for one user branches into two or more streams and is transmitted through different transmission antennas, as indicated by 513 and 515.

FIG. 4 is a block diagram of an OTD transmitter with two transmission antennas (N=2), for example, for a base station in a mobile communication system. The following description is conducted with the understanding that $[\mathbf{W}_m\ -\mathbf{W}_m]$ is identical to $[\mathbf{W}_m\ \overline{\mathbf{W}_m}]$.

Referring to FIG. 4, the OTD transmitter operates in the same manner as the NTD transmitter of FIG. 3, except for a serial-to-parallel conversion process. In the OTD structure, mapped data branches into N streams as many as the transmission antennas in S/P converters 413, 415, and 417, and orthogonally modulated in multipliers 419, 421, 423, and 425, for maintaining mutual orthogonality between the transmission antennas.

Besides the orthogonal modulation, orthogonal codes should be extended to

ensure the mutual orthogonality among the antennas. The orthogonal code extension is accomplished by Hadamard matrix extension. In the case of the OTD transmitter with two transmission antennas A and B shown in FIG. 4, different orthogonal codes assigned to the antennas are $[W_m\ W_m]$ and $[W_m\ -W_m]$ extended from an orthogonal code W_m of a length 2^m used in the NTD transmitter. The purpose of orthogonal code extension is to compensate for a data rate of each of the N streams, which is an 1/N of the data rate prior to serial-to-parallel conversion.

A receiver for receiving a signal from such an OTD transmitter requires signal demodulators for demodulating user data, a pilot demodulator for providing timing and phase information needed in the signal demodulators, and a parallel-to-serial (P/S) converter for converting M signal demodulator outputs to a serial signal stream.

A pilot channel is used for a base station to provide timing and phase information to a mobile station. The mobile station first activates the pilot demodulator to acquire necessary information and demodulates user data based on the acquired information. Each transmission antenna should be assigned a pilot channel.

In the receiver corresponding to the conventional OTD transmitter of FIG. 4, the pilot demodulator subjects a received signal to PN despreading and orthogonal demodulation and integrates the resulting signal for one cycle in order to demodulate a pilot channel from the received signal. A time estimator and a phase estimator in the pilot demodulator estimate timing and phase values from the integrated value.

A signal demodulator of the receiver performs PN despreading on a user data signal based on the timing information received from the pilot demodulator. A phase error which occurs during transmission is compensated for by multiplying the phase information by an integrated value resulting from integrating an orthogonally modulated signal for one cycle. The phase-compensated integrator output is converted to a probability value by a soft decision block and fed through the P/S converter to a deinterleaver.

Despite improvement of reception performance as compared to the NTD system, the conventional OTD mobile communication system, however, has the following problems.

First of all, a terminal should be equipped with pilot demodulators and signal demodulators, each as many as transmission antennas of a base station. This increases the complexity, cost, and power consumption of a receiver.

Another problem is that the length of an orthogonal code used is increased by N times from that of an NTD case, for N transmission antennas. Therefore, an integration interval is extended, degrading the reception performance in a frequency error-susceptible channel environment.

Further, the number of available transmission antennas is limited to 2^n. In other words, the number of transmission antennas is a power of 2, increased to 2, 4, 8, 16, .. in this order, which imposes constraints on several applications including an antenna array.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a TSTD (Time Switched Transmission Diversity) device in which a transmit signal of a base station is distributed to a plurality of antennas by time switching.

Another object of the present invention is to provide a receiver for receiving a signal from a TSTD transmitter.

A further object of the present invention is to provide a TSTD communication device and method in a mobile communication system, in which the length of an orthogonal code is not changed.

Still another object of the present invention is to provide a receiver and a receiving method in a TSTD mobile communication system, in which a single signal demodulator is offered regardless of the number of transmission antennas.

A yet another object of the present invention is to provide a transmitter and a transmitting method in a TSTD mobile communication system, in which the number of transmission antennas can be easily increased.

According to one aspect of the present invention, the above objects are achieved by providing a time diversity transmitting device in a base station of a mobile communication system. The transmitting device has a plurality of transmission antennas, RF (Radio Frequency) transmitters as many as the transmission antennas and connected to their corresponding transmission antennas, for outputting signals on a forward link, a controller for generating a switch

controlling signal in a non-overlapped time cycle, an orthogonal modulator for modulating a transmit signal by an orthogonal code, a spreader for spreading the output of the orthogonal modulator, and a switch connected to an output terminal of the spreader, for connecting the output of the spreader to a corresponding transmitter based on the switch controlling signal.

According to another aspect of the present invention, there is provided a receiving device in a mobile station of a mobile communication system. The receiving device has a pilot channel receiver for detecting a pilot channel signal from an input forward link signal and generating estimated phase and time values, a controller for generating a selection control signal based on cycle information and switching pattern information, in synchronization of a reference time to a base station, a selector for selectively outputting the estimated phase and time values received from the pilot channel receiver based on the selection control signal, and a traffic channel receiver for detecting a traffic channel signal at the selected estimated time position and correcting a phase error of the detected traffic channel signal based on the estimated phase value, for signal decoding.

BRIEF DESCRIPTION OF THE DRAWINGS

The above objects and advantages of the present invention will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIG. 1 is a view illustrating diversity techniques on forward and reverse links in a mobile communication system;

FIG. 2 is a block diagram of a transmission diversity-based device on a forward link in a mobile communication system;

FIG. 3 is a block diagram of an NTD transmitter in a mobile communication system;

FIG. 4 is a block diagram of a conventional OTD transmitter in a mobile communication system;

FIG. 5 illustrates the structures of data transmitted from the transmitters shown in FIGs. 3 and 4;

FIG. 6 is a block diagram of a TSTD transmitter in a mobile communication system according to an embodiment of the present invention;

FIG. 7 is a block diagram of a controller shown in FIG. 6;

FIG. 8 is a view illustrating timing characteristics of data transmitted in a periodic pattern from the TSTD transmitter of FIG. 6;

FIG. 9 is a view illustrating timing characteristics of data transmitted in a random pattern from the TSTD transmitter of FIG. 6;

FIG. 10 is a view illustrating timing characteristics of data for plural users synchronously transmitted from the TSTD transmitter of FIG. 6;

FIG. 11 is a view illustrating timing characteristics of data for plural users asynchronously transmitted from the TSTD transmitter of FIG. 6;

FIG. 12 is a view referred to for describing extensibility of transmission antennas in number in the TSTD transmitter of the mobile communication system according to the embodiment of the present invention;

FIG. 13 is a block diagram of an embodiment of a receiving deice for receiving data from a TSTD transmitting device in the mobile communication system according to the present invention; and

FIG. 14 is a block diagram of another embodiment of a receiving device for receiving data from a TSTD transmitting device in the mobile communication system according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A mobile communication system according to an embodiment of the present invention distributes user data to a plurality of antennas by time switching on a transmission side to achieve a transmission diversity, and demodulates the time diversity-based signal in a single signal demodulator on a reception side. The features of time diversity according to the present invention lie in:

(1) A signal demodulator is given for demodulating user data regardless of the number N of transmission antennas. That is, only one orthogonal code is available to a user, which enables simplification of a receiver and low power dissipation and low cost of a terminal;

(2) The length of an orthogonal code is the same as that of an orthogonal code used in an NTD device, regardless of the number N of transmission antennas. This implies that there is no increase of an integration interval which is involved in providing time diversity; and

(3) The number of available transmission antennas is not limited to 2^n but limitlessly extensible, thereby imposing no constraints on other applications.

Prior to a description in structure and operation of a transmitter in a base station and a receiver in a terminal according to the embodiment of the present invention, it is to be noted that a TSTD scheme of implementing a time diversity on transmission antennas by time switching is applied to a forward link in a mobile communication system of the present invention.

FIG. 6 is a block diagram of a TSTD transmitter with two (N=2) transmission antennas in a base station according to the present invention.

Referring to FIG. 6, a signal mapper 611 receives a signal resulting from combining encoded user data with a long code and changes the level of the received signal by converting 0s and 1s to +1s and −1s, respectively. An S/P converter 613 converts a serial signal received from the signal mapper 611 to an odd-numbered signal and an even-numbered signal. A multiplier 615 multiplies the even-numbered signal by an orthogonal code $\mathbf{W}_m$ and a multiplier 617 multiplies the odd-numbered signal by an orthogonal code $\mathbf{W}_m$. These multipliers 615 and 617 function to subject a user signal to orthogonal modulation (or orthogonal spreading) by multiplication. The orthogonal code can be a Walsh code. A PN spreader 619 multiplies the orthogonally modulated signals received from the multipliers 615 and 617 by corresponding PN sequences PN_I and PN_Q, for PN spreading (or PN masking) of a signal to be transmitted.

A controller 600 generates a switch controlling signal for distributing a transmit signal to a plurality of antennas in the TSTD transmitter of the present invention. The controller 600 synchronizes to a GPS (Global Positioning System) signal in a synchronous mode and a switching cycle is an integer multiple of the orthogonal code length. In addition, a look-up table for storing switching information with respect to a hopping pattern should be provided to the controller 600 in the case of implementing the time switching in a specific pattern. The controller 600 is configured in FIG. 7 and a description of its operation will be given later. A switch 621 switches based on the output of the controller 600, and has a common terminal coupled to output terminals of the PN spreader 619 from which I channel and Q channel spread signals are transmitted, a first output terminal coupled to LPFs 623 and 625, and a second output terminal coupled to LPFs 627 and 629. The switch 621 switches based on a switch controlling signal received from the controller 600 and selectively outputs the spread signals received from the

PN spreader 619 to the LPFs 623 and 625 or to the LPFs 627 and 629.

The LPFs 623 and 625 low-pass-filter the I channel and Q channel PN spread signals received from the switch 621. Multipliers 631 and 633 multiply outputs of the LPFs 623 and 625 by carriers, for frequency upconversion. An adder 641 adds signals received from the multipliers 631 and 633 and sends the resulting signal to a transmission antenna A.

The LPFs 627 and 629 low-pass-filter the I channel and Q channel PN spread signals received from the switch 621. Multipliers 635 and 637 multiply outputs of the LPFs 627 and 629 by carriers, for frequency upconversion. An adder 643 adds signals received from the multipliers 631 and 633 and sends the resulting signal to a transmission antenna B.

The structure shown in FIG. 6 can be adapted as a forward channel transmitter in the TSTD base station. Forward channel transmitters include a pilot channel transmitter, a sync channel transmitter, a control channel transmitter, and a traffic channel transmitter. Considering that a pilot channel provides time synchronization for transmission of data on a forward link, the pilot channel transmitter can be configured to be an OTD structure, while the other channel transmitters can use the TSTD structure shown in FIG. 6.

FIG. 7 is a block diagram of the controller 600 shown in FIG. 6. Referring to FIG. 7, a reference cycle register 711 stores a reference cycle signal received from an upper-level processor. The reference cycle signal acts as a time switching cycle in a channel transmitter. A clock counter 713 receives clock pulses from a base station system, counts the clock pulses in a reference cycle unit, and generates

read pulses. A look-up table 715 stores switching pattern information received from the upper-level processor and outputs corresponding switching information in response to the read pulses received from the clock counter 713. A control signal generator 717 generates a switch controlling signal for distributing a PN spread signal to a plurality of transmission antennas according to the pattern information read from the look-up table 715.

By way of example, the controller 600 of FIG. 7 functions to switchingly connect a baseband transmit output to N antennas by periods in a TSTD base station transmitter. The reference cycle register 711 stores a time switching cycle for a channel so that each channel can be time-switched differently. That is, designating a different reference cycle signal for each channel in the reference cycle register 711 results in transmission of each channel in a different switching cycle. The value stored in the reference cycle register 711 is designated separately for each channel in the upper-level processor prior to transmission of the channel, and can be changed during data transmission under a separately determined control.

The clock pulses input to the clock counter 713 are provided from the base station system, synchronized to a reference time in the base station, and have a clock cycle proportional to an orthogonal code length. The clock counter 713 counts the clock pulses, compares the counted value with the value stored in the reference cycle register 711, and sends read pulses to the look-up table 715 at the time point when the values are equal.

The look-up table 715 is a memory for storing a time switching pattern of data transmitted through the N transmission antennas. A different switching pattern can be assigned to each channel, or channels can share the same switching pattern.

The switching pattern stored in the look-up table 715 is to be transmitted from the base station to the terminal to allow the terminal to demodulate data based on the switching pattern.

The control signal generator 717 analyses the switching pattern read from the look-up table 715 and controls signal paths to the N transmission antennas. That is, only one selected transmission antenna is enabled and the other transmission antennas are disabled.

Hence, the controller 600 counts input clock pulses, compares the counted value with a reference cycle value, and generates a read signal corresponding to a switching pattern stored in the look-up table 715 if the values are equal. Here, the switching pattern is information used to select a transmission antenna in a subsequent step. The thus-obtained switching information is changed to an enable/disable signal for each transmission path.

FIG. 8 is a view illustrating a comparison between characteristics of signals transmitted from an NTD transmitter and the TSTD transmitter shown in FIG. 6. In FIG. 8, reference numeral 811 denotes an output timing of the NTD transmitter. Reference numerals 813 and 815 denote the timings of signals respectively transmitted through the transmission antennas A and B in the TSTD transmitter.

In operation, the TSTD transmitter uses one orthogonal code assigned to a corresponding user, as compared to the OTD transmitter requiring orthogonal codes as many as transmission antennas, and follows the same process as the NTD transmitter, up to PN spreading. Then, PN spread data is switched to each transmission antenna in a cycle equal to an integer multiple of an orthogonal code

length, in a periodic pattern indicating sequential transmission of data to the N transmission antennas or in a random pattern. Which time switching pattern to use is determined by the output of the look-up table 715 in the controller 600, and a time switching cycle is determined by a reference cycle value stored in the reference cycle register 711.

The time switching scheme can take a random pattern as shown in FIG. 9 as well as a periodic pattern as shown in FIG. 8. That is, if the look-up table 715 is loaded with a switching pattern requiring that data should be connected to the transmission antenna A consecutively twice and then to the transmission antenna B once in the TSTD transmitter of FIG. 6, the controller 600 controls the switch 621 to connect the output of the PN spreader 619 to the LPFs 623 and 625 for two switching cycles and to the LPFs 627 and 629 for one switching cycle. As a result, the timings of signals output from the transmission antennas A and B are shown as indicated by 913 and 915 of FIG. 9, respectively. Time switching in the random pattern can additionally offer the data scrambling effect.

FIG. 10 is a timing diagram of user data under the condition that N=2, two users, and synchronous time switching in the TSTD transmitter of a base station, and FIG. 11 is a timing diagram of user data under the condition that N=2, two users, and asynchronous time switching in the TSTD transmitter. Synchronous time switching is discriminated from asynchronous time switching depending upon whether an identical time switching scheme or different time switching schemes are applied to all terminals for a base station.

The TSTD technique of the present invention overcomes the conventional limitation encountered with the OTD technique. Because of assignment of one

orthogonal code to a user, a receiver may demodulate all user data signals in a single demodulator regardless of the number of transmission antennas. Furthermore, use of the same orthogonal code as that in the NTD transmitter brings about no extension of an integration interval. While the number of transmission antennas is limited to 2^n in the OTD transmitter, it is limitless (N is an integer) in the present invention. FIG. 12 is a timing diagram of user data transmitted from the TSTD transmitter and the OTD transmitter in comparison, with N of 3 and a periodic pattern. As shown in the drawing, the TSTD transmitter can afford time diversity with three transmission antennas, which is impossible in the OTD one.

There may be two types of receiving devices for a terminal corresponding to a TSTD transmitting device. In one type, OTD is applied to a pilot channel and TSTD to the other channels. In the other type, TSTD is applied to all channels including a pilot channel and user data channels. FIGs. 13 and 14 are block diagrams of such two types of receiving devices. Because the pilot channel is a common channel for supporting synchronous demodulation in a terminal, either OTD or TSTD with a predetermined cycle and pattern can be rendered to transmission of the pilot channel.

FIG. 13 is a block diagram of a receiving device for receiving a signal from a transmitting device having two transmission antennas, a TSTD traffic channel transmitter, and an OTD pilot channel transmitter. Referring to FIG. 13, the receiving includes pilot channel receivers as many as the transmission antennas of the transmitting device. The pilot channel receivers should use orthogonal codes extended in length proportionally to the number of the transmission antennas. In FIG. 13, two pilot channel receivers 1310 and 1320 are provided due to two transmission antennas. An input signal is a baseband signal.

In the pilot channel receiver 1310, a PN despreader 1311 multiplies an input signal by a PN sequence, for PN despreading. A multiplier 1313 orthogonally demodulates the signal received from the PN despreader 1311 by multiplying the received signal by the same orthogonal code $[W_m\ W_m]$ as one used in the pilot channel transmitter. An integrator 1315 integrates a signal received from the multiplier 1311 for a time T and sums the integrated values. A phase estimator 1317 analyses a signal received from the integrator 1315 and outputs an estimated phase value 0 of the pilot signal received through the transmission antenna A. A time estimator 1319 analyses the signal received from the integrator 1315 and outputs an estimated time value 0 as the transmission time of the pilot signal received through the transmission antenna A.

In the pilot channel receiver 1320, a PN despreader 1321 multiplies the input signal by a PN sequence, for PN despreading. A multiplier 1323 orthogonally demodulates the signal received from the PN despreader 1321 by multiplying the received signal by the same orthogonal code $[W_m\ \overline{W_m}]$ as the other used in the pilot channel transmitter. An integrator 1325 integrates a signal received from the multiplier 1321 for a time T and sums the integrated values. A phase estimator 1327 analyses a signal received from the integrator 1325 and outputs an estimated phase value 1 of the pilot signal received through the transmission antenna B. A time estimator 1329 analyses the signal received from the integrator 1325 and outputs an estimated time value 1 as the transmission time of the pilot signal received through the transmission antenna B.

A controller 1341 synchronizes to a reference time of the base station and generates a control signal for selecting the outputs of the pilot channel receivers 1310 and 1320 in a time switching cycle unit. A selector 1343 selectively outputs

the estimated phase and time values received from the pilot channel receivers 1310 and 1320 on the basis of the control signal of the controller 1341.

In a traffic channel receiver 1330, a PN despreader 1331 multiplies an input signal at a transmission time position indicated by the time signal received from the selector 1343 by a PN sequence. That is, the PN despreader 1331 despreads the input signal by the PN code at the estimated switching time position. A multiplier 1333 multiplies the orthogonal code [W_n] used in the traffic channel transmitter by a signal received from the PN despreader 1331. An integrator 1335 integrates a signal received from the multiplier 1333 for the time T and sums the integrated values. A phase sign converter 1345 changes the sign of the phase value received from the selector 1343. A multiplier 1337 multiplies the output of the integrator 1335 by the output of the phase sign converter 1345, to synchronize the phase of the input signal. A level decision block 1339 detects the level of a signal received from the multiplier 1337 and changes the signal level to a gray level. The signal output from the level decision block 1339 is fed to a decoder in the receiver.

The receiving device shown in FIG. 13 includes pilot channel demodulators as many as the N transmission antennas, here, two antennas. These pilot channel receivers are the same as OTD ones in configuration and operation. On the other hands, there is given the single traffic channel receiver 1330 because of modulation of user data distributed to the transmission antennas using an identical orthogonal code.

The estimated time and phase information for the N transmission antennas is selectively provided from the pilot channel receivers 1310 and 1320 to the traffic channel receiver 1330 by the selector 1343 based on the clock signal of the

controller 1341 synchronized to the base station. That is, the terminal obtains switching cycle and pattern information from the base station during a call set-up.

The controller 1341 obtains a current switching scheme applied to the system by demodulating a sync channel based on time and phase information pilot obtained from a demodulated pilot channel and analysing information loaded on the demodulated sync channel. Upon detection of the switching scheme for TSTD in a receiving device, the terminal can be synchronized to the base station in terms of time switching.

The traffic channel receiver 1330 subjects a user data signal to PN despreading using the estimated time value selectively received from the selector 1343 and orthogonally demodulates the PN spread signal. Then, it integrates the orthogonal modulation signal for one cycle, and multiplies the integrated value by a value obtained from converting the sign of phase information selected by the selector 1343, to thereby compensate for a phase error which occurs during data transmission. The phase-compensated integrator output is subjected to soft decision and converted to a probability value in the level decision block 1339 and fed through a P/S converter (not shown) to a deinterleaver (not shown).

FIG. 14 is a block diagram of another embodiment of a receiving device for receiving a signal from a transmitting device having a TSTD structure for all channel transmitters. Hence, the receiving device in this embodiment includes a single pilot channel receiver since a pilot channel signal is also time switched for transmission.

In a pilot channel receiver 1410, a PN despreader 1411 multiplies an input

signal by a PN sequence, for PN despreading. A multiplier 1413 orthogonally demodulates the signal received from the PN despreader 1411 by multiplying the received signal by the same orthogonal code W_m as that used in a corresponding pilot channel transmitter. An integrator 1415 integrates a signal received from the multiplier 1411 for a time T and sums the integrated values. A phase estimator 1417 analyses a signal received from the integrator 1415 and outputs an estimated phase value of a pilot channel signal received through transmission antennas. A time estimator 1419 analyses the signal received from the integrator 1415 and outputs an estimated time value as the transmission time of the pilot channel signal received through the transmission antennas.

A controller 1441 synchronizes to a reference time of the base station and generates a control signal for selecting the outputs of the pilot channel receiver 1410 in a time switching cycle unit. A selector 1443 selectively outputs the estimated phase and time values received from the pilot channel receiver 1410 on the basis of the control signal of the controller 1441.

In a traffic channel receiver 1420, a PN despreader 1421 multiplies an input signal at a time position indicated by the time signal received from the selector 1343 by a PN sequence. That is, the PN despreader 1421 despreads the input signal by the PN code at the estimated switching time position. A multiplier 1423 multiplies the orthogonal code $[W_n]$ used in a corresponding traffic channel transmitter by a signal received from the PN despreader 1421. An integrator 1425 integrates a signal received from the multiplier 1423 for the time T and sums the integrated values. A phase sign converter 1431 changes the sign of the phase value received from the selector 1443. A multiplier 1427 multiplies the output of the integrator 1425 by the output of the phase sign converter 1431, to synchronize the phase of the

input signal. A level decision block 1429 detects the level of a signal received from the multiplier 1427 and changes the signal level to a gray level. The signal output from the level decision block 1429 is fed to a decoder in the receiver.

The receiving device shown in FIG. 14 shows an example where TSTD is executed on a pilot channel as well as traffic channels. Since one orthogonal code is used for the pilot channel, which differs from the receiving device of FIG. 13, all necessary timings and estimated phases can be generated by the use of the single pilot channel receiver 1410 with implementation of the same time switching technique as that for the traffic channel receiver 1420.

TSTD on a forward link in a mobile communication system offers the following effects:

(1) only one traffic channel receiver is needed for demodulating user data regardless of the number N of transmission antennas, since one orthogonal code is available to a user, which enables simplification of a receiver and low power dissipation and low cost of a terminal;

(2) The length of an orthogonal code is not changed because of use of an orthogonal code used in an NTD device. Therefore, there is no increase of an integration interval which is involved in providing time diversity and no degradation of the reception performance possibly caused by a channel environment such as a frequency error;

(3) The number of available transmission antennas is not limited, thereby imposing no constraints on other applications; and

(4) A scrambling effect can be added to improvement in reception performance by applying different switching techniques to users in a base station.

While the present invention has been described in detail with reference to the specific embodiments, they are mere exemplary applications. Thus, it is to be clearly understood that many variations can be made by anyone skilled in the art within the scope and spirit of the present invention.

WHAT IS CLAIMED IS:

1. A transmitting device in a mobile communication system, comprising:

a spreader for spreading a transmit signal;

at least two antennas;

a plurality of RF transmitters connected to the antennas, for converting an input signal to an RF signal and outputting the RF signal through the antennas; and

a time switching transmission controller connected between the spreader and the RF transmitters, for switching the output of the spreader in a predetermined time unit and distributing the resulting signal to the RF transmitters without overlap.

2. The transmitting device of claim 1, wherein the time switching transmission controller comprises:

a controller having switching patterns, for generating a switch controlling signal based on a switching pattern at a predetermined time; and

a switch connected between an output terminal of the spreader and input terminals of the RF transmitters, for switching the output of the spreader to a corresponding RF transmitter based on the switch controlling signal.

3. The transmitting device of claim 2, wherein the controller comprises:

a reference cycle storage for storing a reference switching cycle value;

a counter for counting clock pulses of a base station and outputting the counted value based on the reference switching cycle value;

a memory for storing switching patterns and outputting a switching pattern based on the counted value; and

a control signal generator for generating the switch controlling signal

according to the switching pattern received from the memory.

4. The transmitting device of claim 3, wherein the memory stores at least one of a sequential switching pattern, a random switching pattern, a switching pattern with a uniform switching cycle, and a switching pattern with a variable switching cycle, and the control signal generator generates the switch controlling signal as long as an integer multiple of an orthogonal code length.

5. A transmitting device in a mobile communication system, comprising:

a plurality of dedicated channel transmitters, each having at least two antennas, a plurality of RF transmitters connected to the antennas, for converting an input signal to an RF signal and outputting the RF signal through the antennas, a dedicated channel spreader for spreading a dedicated channel signal, and a time switching transmission controller connected between the dedicated channel spreader and the RF transmitters, for switching the output of the spreader in a predetermined time unit and distributing the resulting signal to the RF transmitters without overlap; and

a pilot channel transmitter having a symbol distributor for distributing pilot channel symbols to the antennas, a plurality of orthogonal spreaders for spreading the distributed symbols by different orthogonal codes, and a plurality of PN spreaders for spreading the orthogonally spread signals by PN codes and outputting the PN spread signals to the RF transmitters.

6. The transmitting device of claim 5, wherein the time switching transmission controller comprises:

a controller having switching patterns, for generating a switch controlling signal based on a switching pattern at a predetermined time; and

a switch connected between an output terminal of the spreader and input terminals of the RF transmitters, for switching the output of the spreader to a corresponding RF transmitter based on the switch controlling signal.

7. The transmitting device of claim 6, wherein the controller comprises:

a reference cycle storage for storing a reference switching cycle value;

a counter for counting clock pulses of a base station and outputting the counted value based on the reference switching cycle value;

a memory for storing switching patterns and outputting a switching pattern based on the counted value; and

a control signal generator for generating the switch controlling signal according to the switching pattern received from the memory.

8. The transmitting device of claim 7, wherein the memory stores at least one of a sequential switching pattern, a random switching pattern, a switching pattern with a uniform switching cycle, and a switching pattern with a variable switching cycle, and the control signal generator generates the switch controlling signal as long as an integer multiple of an orthogonal code length.

9. A channel receiving device in a mobile communication system, comprising:

a pilot channel receiver for despreading a pilot channel signal from an input signal and estimating phase and time values;

a reception controller for selecting the estimated phase and time values according to the switching cycle and pattern of a TSTD (time switching transmission diversity) signal received from a base station through at least two antennas; and

a traffic channel receiver for receiving the TSTD signal from the base station, detecting a channel signal based on the estimated time value, and correcting a phase error of the detected channel signal based on the estimated phase value, for demodulation.

10. The channel receiving device of claim 9, wherein the traffic channel receiver comprises:

a PN despreader for PN-despreading the input signal at a time position indicated by the estimated time value;

an orthogonal despreader for depreading the PN-despread signal by a corresponding channel orthogonal code; and

a demodulator for correcting a phase error of the orthogonal despread signal based on the estimated phase value.

11. A channel receiving device in a mobile communication system, comprising:

a plurality of pilot channel receivers for receiving OTD (Orthogonal Transmission Diversity) pilot signals through at least two antennas, and estimating phase and time values of corresponding pilot channel signals by despreading the pilot channel signals;

a reception controller for selecting estimated phase and time values according to the switching cycle and pattern of TSTD signals received from a base station through at least two antennas; and

a traffic channel receiver for receiving the TSTD signals, detecting a channel signal based on the estimated time values, and correcting a phase error of the detected channel signal based on the estimated phase values, for demodulation.

12. The channel receiving device of claim 11, wherein the traffic channel receiver comprises:

a PN despreader for PN-despreading the input signal at a time position indicated by the estimated time value;

an orthogonal despreader for depreading the PN-despread signal by a corresponding channel orthogonal code; and

a demodulator for correcting a phase error of the orthogonal despread signal based on the estimated phase value.

13. A channel signal transmitting method in a mobile communication system, comprising the steps of:

spreading a transmit signal by a corresponding orthogonal signal for a dedicated channel;

spreading the orthogonally spread signal by a PN code; and

connecting the PN-spread signal to a corresponding antenna selected from at least two antennas and generating a TSTD signal in a non-overlapped time period according to a predetermined switching pattern.

14. The transmitting method of claim 13, wherein the TSTD signal generating step comprises the substeps of:

generating a switch controlling signal based on the switching pattern at a predetermined time; and

switching the PN-spread signal to a corresponding transmission antenna based on the switch controlling signal.

15. The transmitting method of claim 14, wherein the switch controlling step comprises the substeps of:

generating a reference switching cycle signal;

counting clock pulses of a base station and outputting the counted value at the time point when the reference switching cycle value is generated;

outputting a switching pattern based on the counted value; and

generating the switch controlling signal according to the switching pattern.

16. The transmitting method of claim 15, wherein the switching pattern is at least one of a sequential switching pattern, a random switching pattern, a switching pattern with a uniform switching cycle, and a switching pattern with a variable switching cycle, and the switch controlling signal is an integer multiple of an orthogonal code length.

17. A channel signal receiving method in a mobile communication system, comprising the steps of:

(1) despreading a pilot channel signal from an input signal and estimating phase and time values;

(2) selecting the estimated phase and time values according to the switching cycle and pattern of a TSTD signal received from a base station through at least two antennas; and

(3) detecting a TSTD dedicated channel signal based on the estimated time value, and correcting a phase error of the detected signal based on the estimated phase value, for demodulation.

18. The channel signal receiving method of claim 17, wherein the step (3) comprises the substeps of:

PN-despreading the input signal at a time position indicated by the estimated time value;

depreading the PN-despread signal by a corresponding dedicated channel orthogonal code; and

correcting a phase error of the orthogonal despread signal based on the estimated phase value.

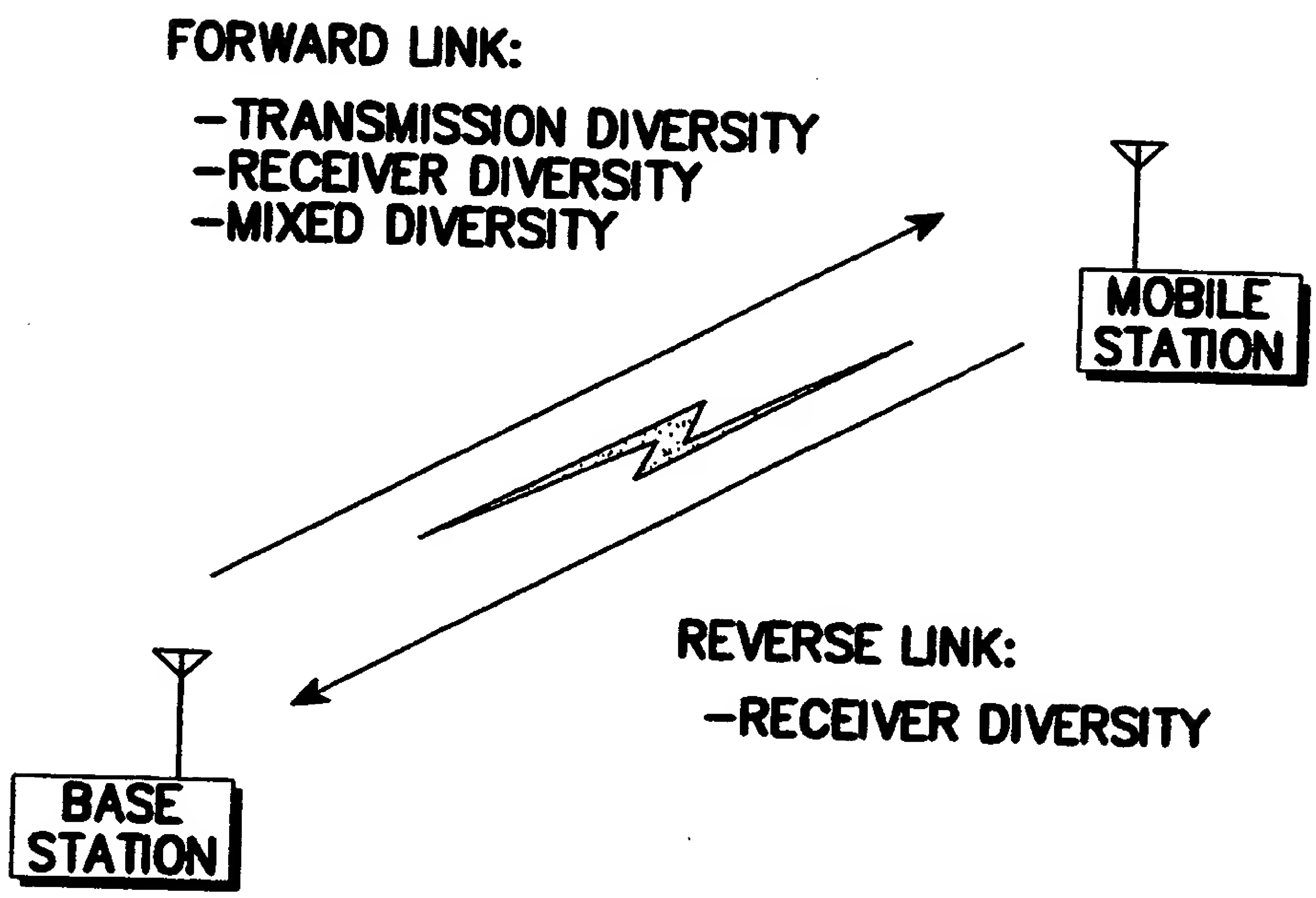
FORWARD LINK:
-TRANSMISSION DIVERSITY
-RECEIVER DIVERSITY
-MIXED DIVERSITY
MOBILE STATION
REVERSE LINK:
-RECEIVER DIVERSITY
BASE STATION

FIG. 1

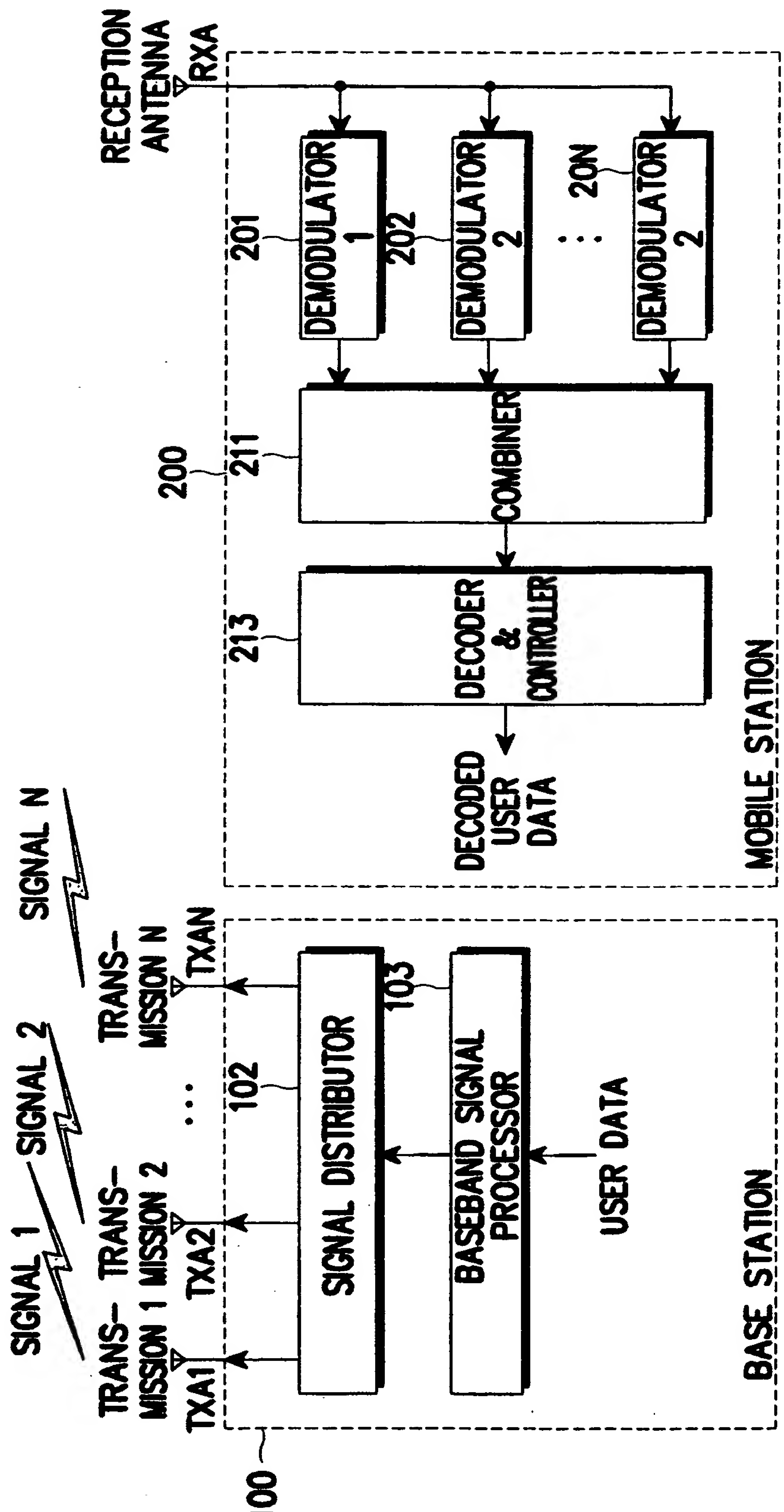
RECEPTION ANTENNA
RXA
201
DEMODULATOR 1
202
DEMODULATOR 2
20N
DEMODULATOR 2
200
211
COMBINER
213
DECODER & CONTROLLER
DECODED USER DATA
MOBILE STATION
SIGNAL 1
SIGNAL 2
SIGNAL N
TRANS-MISSION 1
TXA1
TRANS-MISSION 2
TXA2
TRANS-MISSION N
TXAN
102
SIGNAL DISTRIBUTOR
103
BASEBAND SIGNAL PROCESSOR
USER DATA
BASE STATION
100

FIG. 2

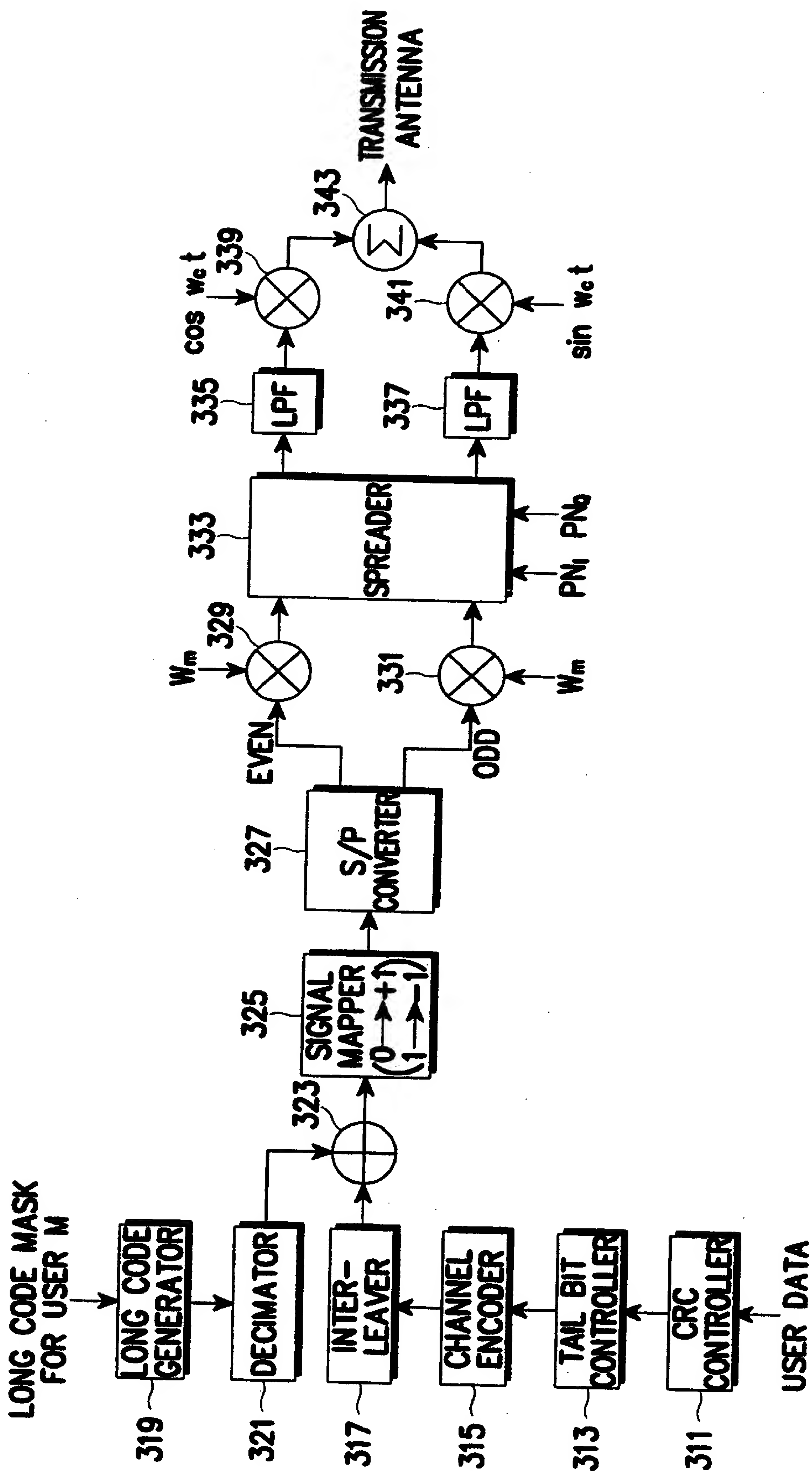
LONG CODE MASK FOR USER M
LONG CODE GENERATOR
DECIMATOR
INTER-LEAVER
CHANNEL ENCODER
TAIL BIT CONTROLLER
CRC CONTROLLER
USER DATA
319
321
317
315
313
311
323
SIGNAL MAPPER (0→+1) (1→-1)
325
S/P CONVERTER
327
EVEN
ODD
W_m
W_m
329
331
SPREADER
333
PN_I
PN_Q
LPF
LPF
335
337
cos w_ct
sin w_ct
339
341
343
TRANSMISSION ANTENNA

FIG. 3

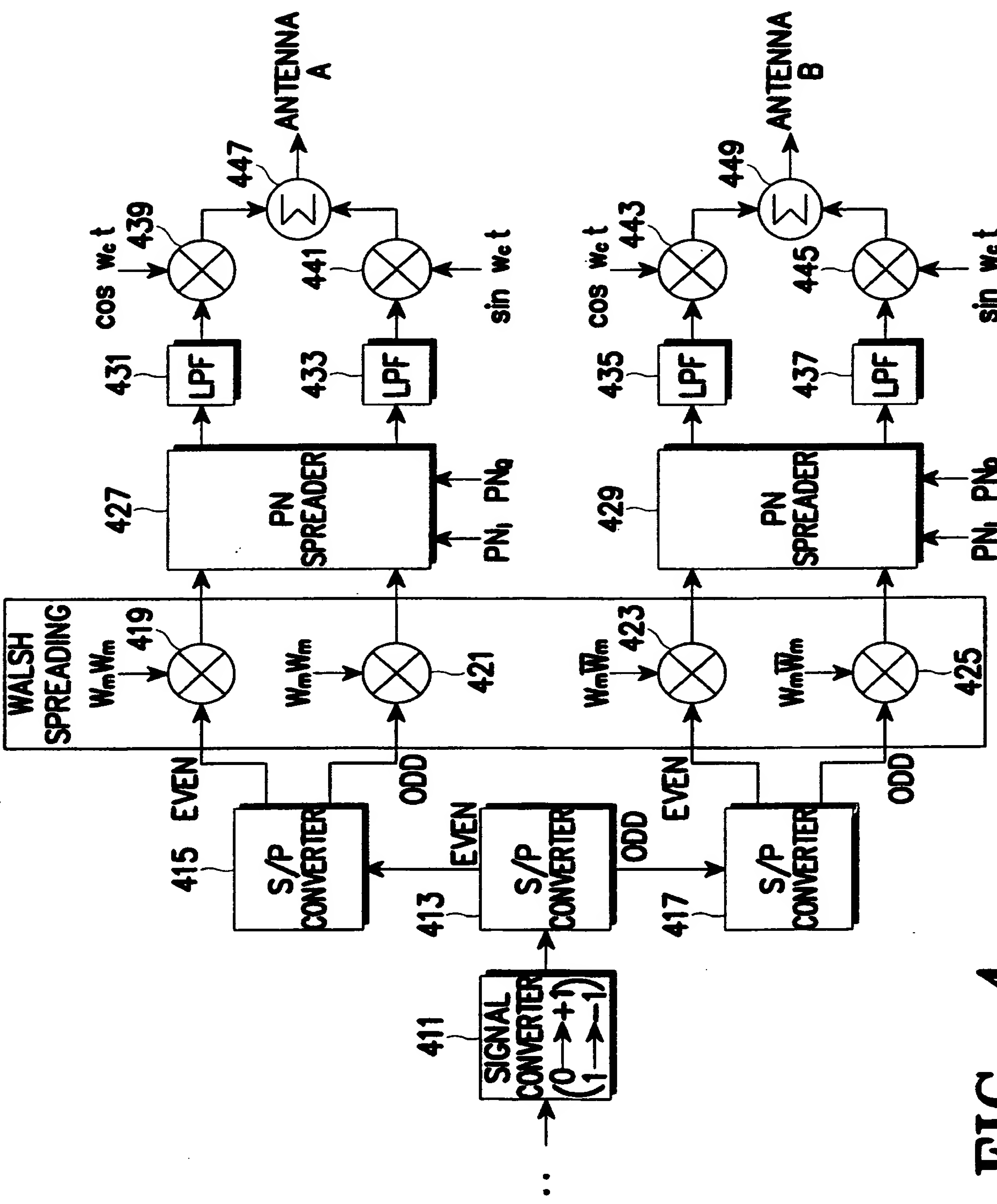
SIGNAL CONVERTER (0→+1) (1→-1)
411
S/P CONVERTER
413
415
417
EVEN
ODD
WALSH SPREADING
W_mW_m
$W_m\overline{W}_m$
419
421
423
425
PN SPREADER
427
429
PN_I
PN_Q
LPF
431
433
435
437
cos w_ct
sin w_ct
439
441
443
445
447
449
ANTENNA A
ANTENNA B

FIG. 4

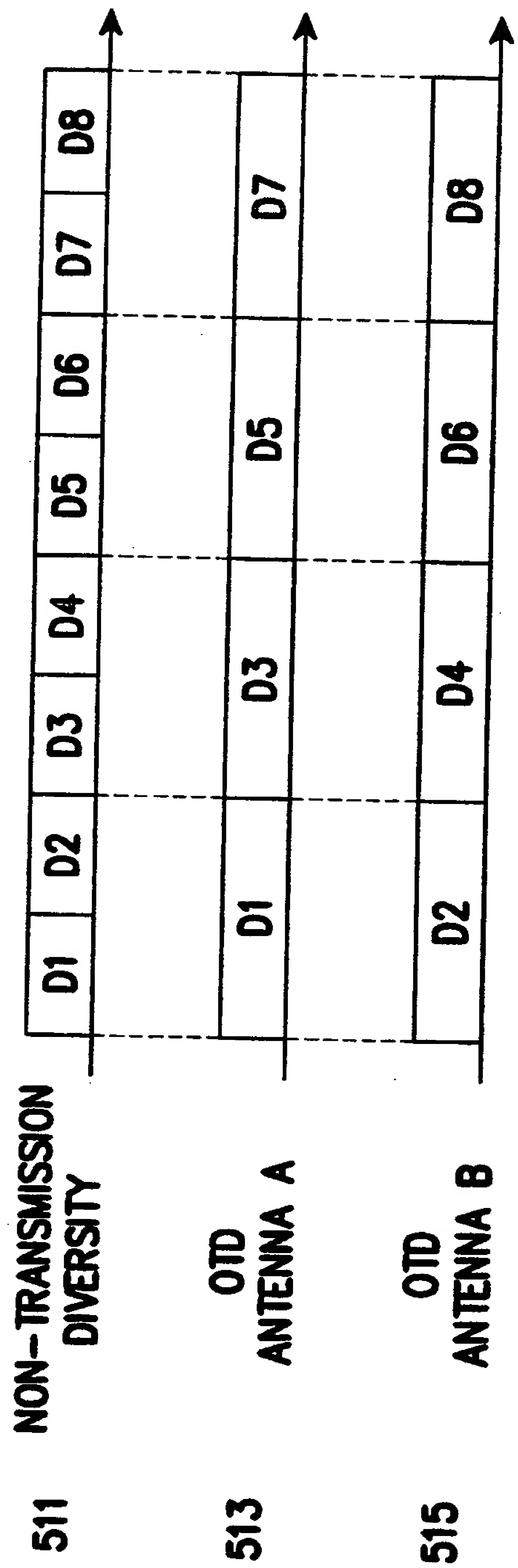
511
NON-TRANSMISSION DIVERSITY
D1
D2
D3
D4
D5
D6
D7
D8
513
OTD ANTENNA A
D1
D3
D5
D7
515
OTD ANTENNA B
D2
D4
D6
D8

FIG. 5

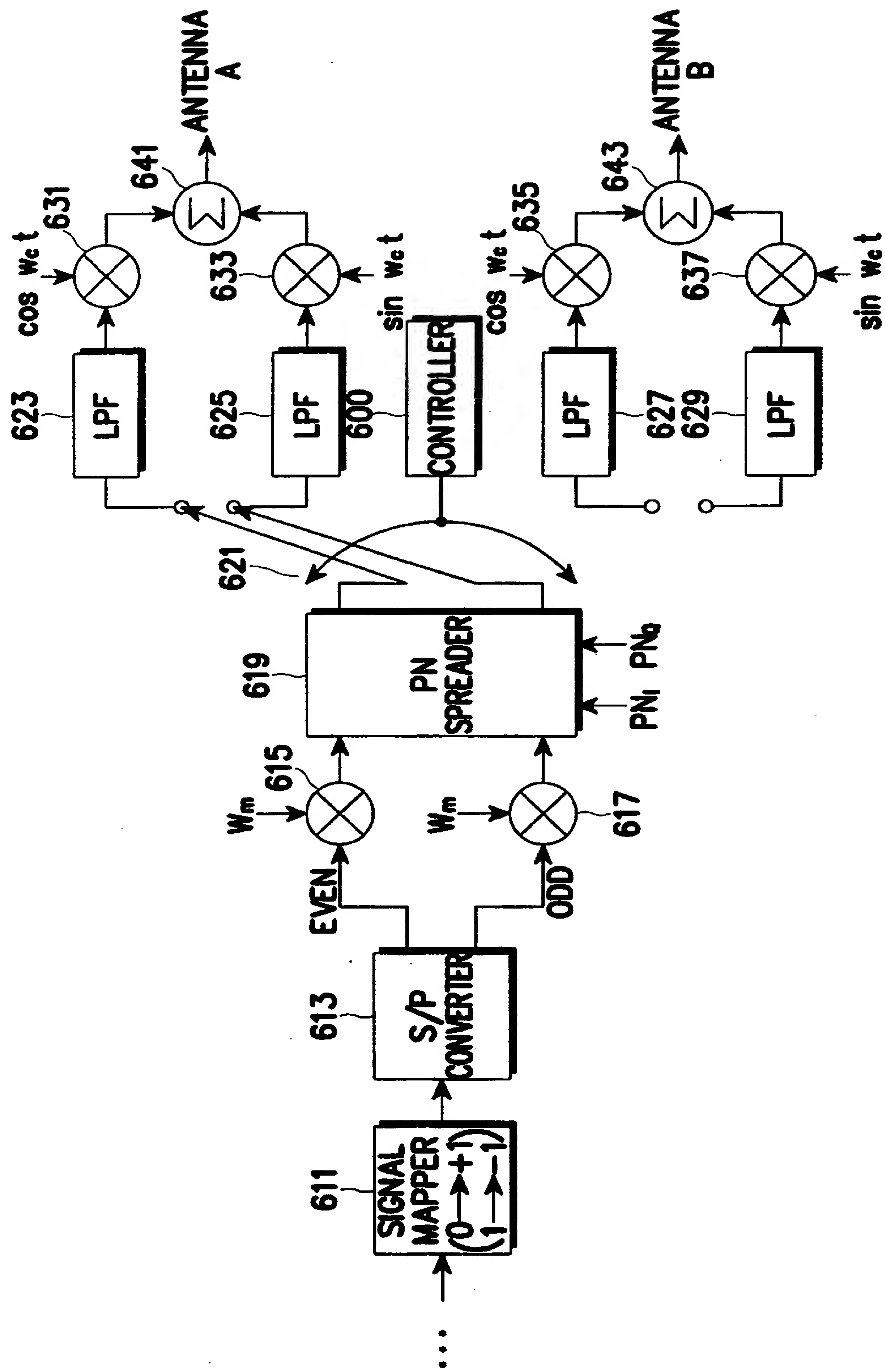
ANTENNA A
ANTENNA B
641
643
631
633
635
637
cos wc t
sin wc t
cos wc t
sin wc t
623
625
627
629
LPF
LPF
LPF
LPF
600
CONTROLLER
621
619
PN SPREADER
PNI PNQ
615
617
Wm
Wm
EVEN
ODD
613
S/P CONVERTER
611
SIGNAL MAPPER (0→+1) (1→−1)

FIG. 6

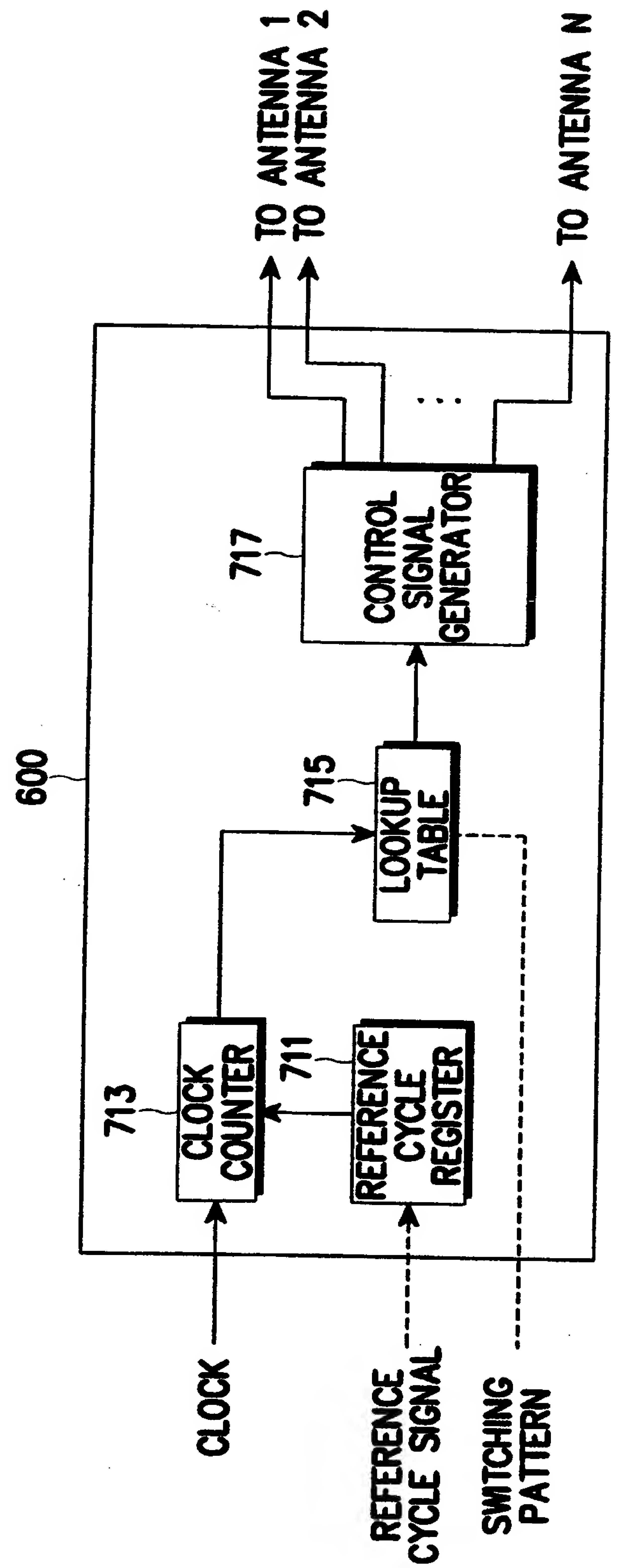
TO ANTENNA 1
TO ANTENNA 2
TO ANTENNA N
600
717
CONTROL SIGNAL GENERATOR
715
LOOKUP TABLE
713
CLOCK COUNTER
711
REFERENCE CYCLE REGISTER
CLOCK
REFERENCE CYCLE SIGNAL
SWITCHING PATTERN

FIG. 7

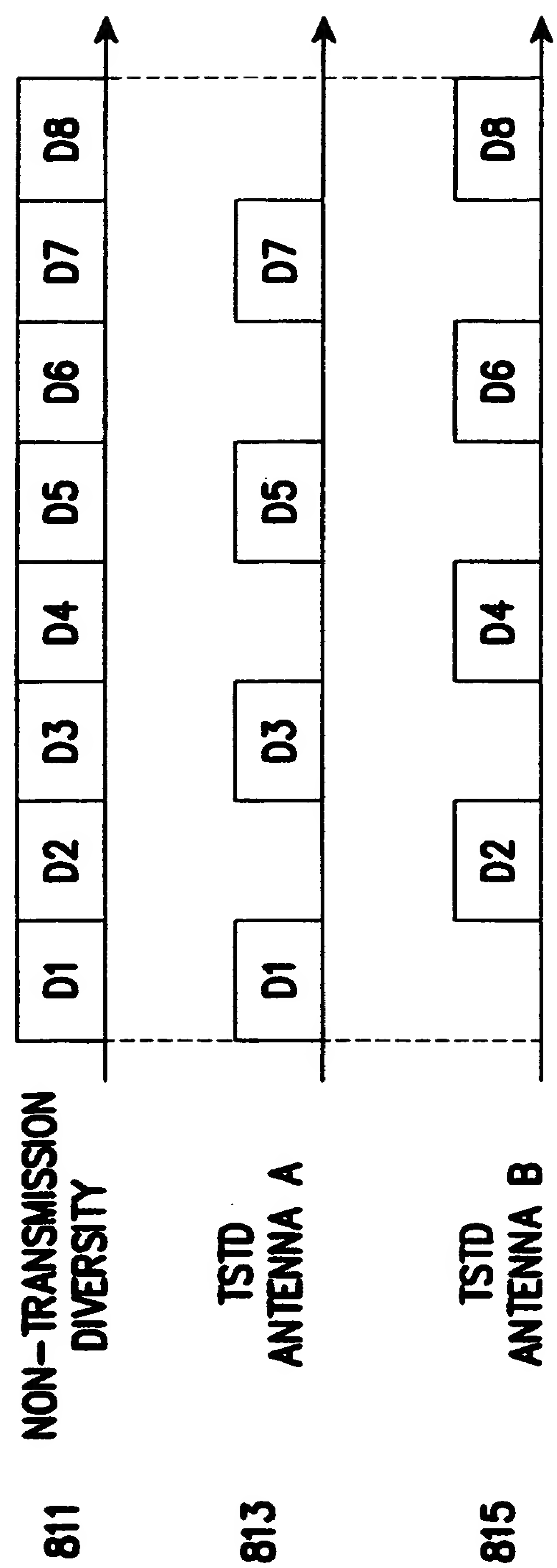
811
NON-TRANSMISSION DIVERSITY
813
TSTD ANTENNA A
815
TSTD ANTENNA B
D1
D2
D3
D4
D5
D6
D7
D8
D1
D3
D5
D7
D2
D4
D6
D8

FIG. 8

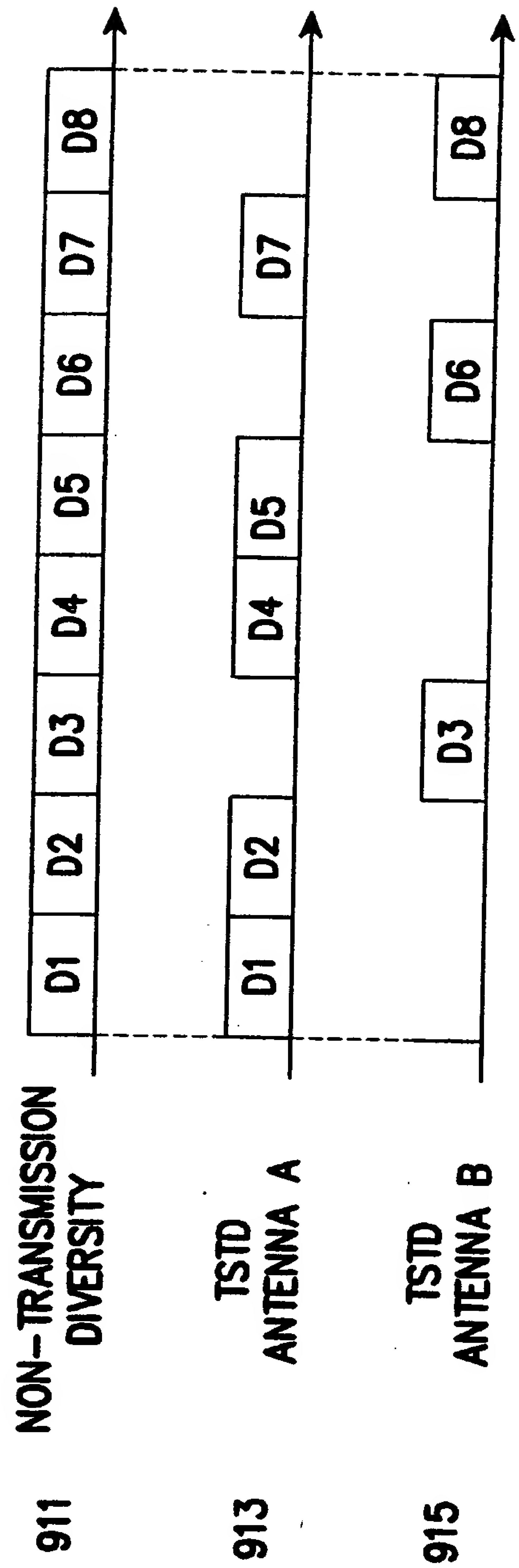
911
NON-TRANSMISSION DIVERSITY
913
TSTD ANTENNA A
915
TSTD ANTENNA B
D1
D2
D3
D4
D5
D6
D7
D8

FIG. 9

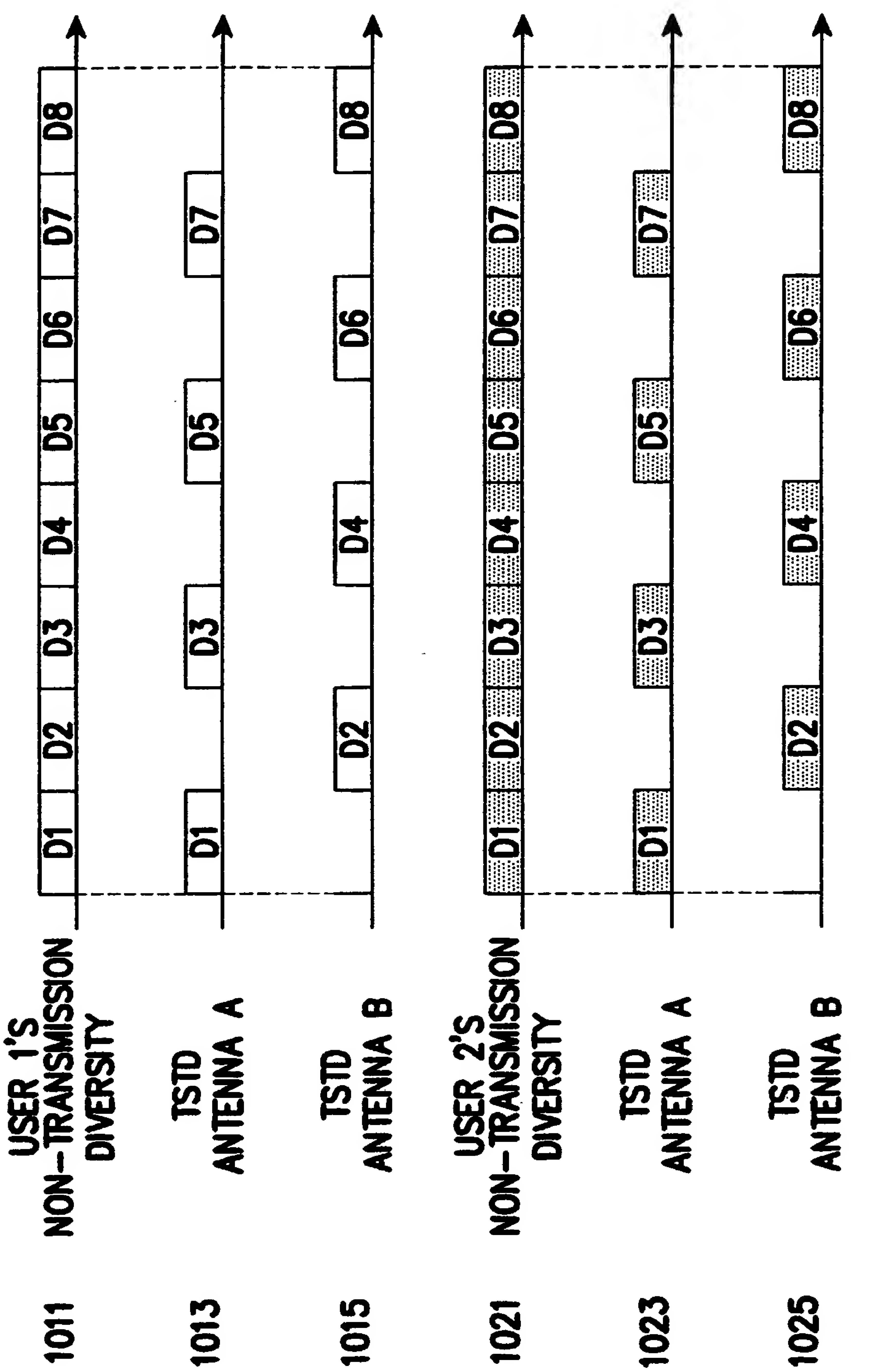
1011
USER 1'S NON-TRANSMISSION DIVERSITY
1013
TSTD ANTENNA A
1015
TSTD ANTENNA B
1021
USER 2'S NON-TRANSMISSION DIVERSITY
1023
TSTD ANTENNA A
1025
TSTD ANTENNA B
D1 D2 D3 D4 D5 D6 D7 D8
D1 D3 D5 D7
D2 D4 D6 D8
D1 D2 D3 D4 D5 D6 D7 D8
D1 D3 D5 D7
D2 D4 D6 D8

FIG. 10

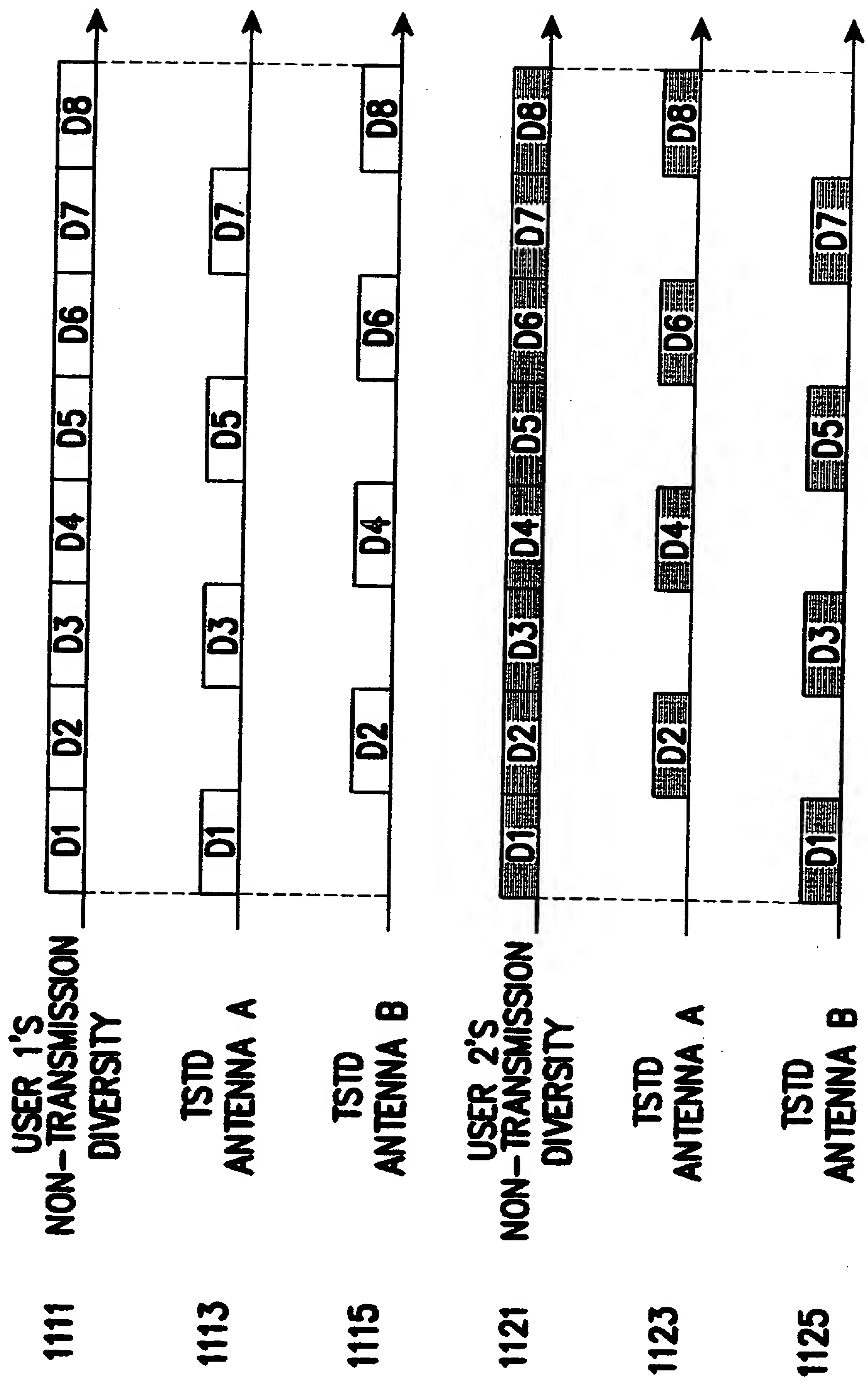
1111
USER 1'S NON-TRANSMISSION DIVERSITY
1113
TSTD ANTENNA A
1115
TSTD ANTENNA B
1121
USER 2'S NON-TRANSMISSION DIVERSITY
1123
TSTD ANTENNA A
1125
TSTD ANTENNA B
D1
D2
D3
D4
D5
D6
D7
D8

FIG. 11

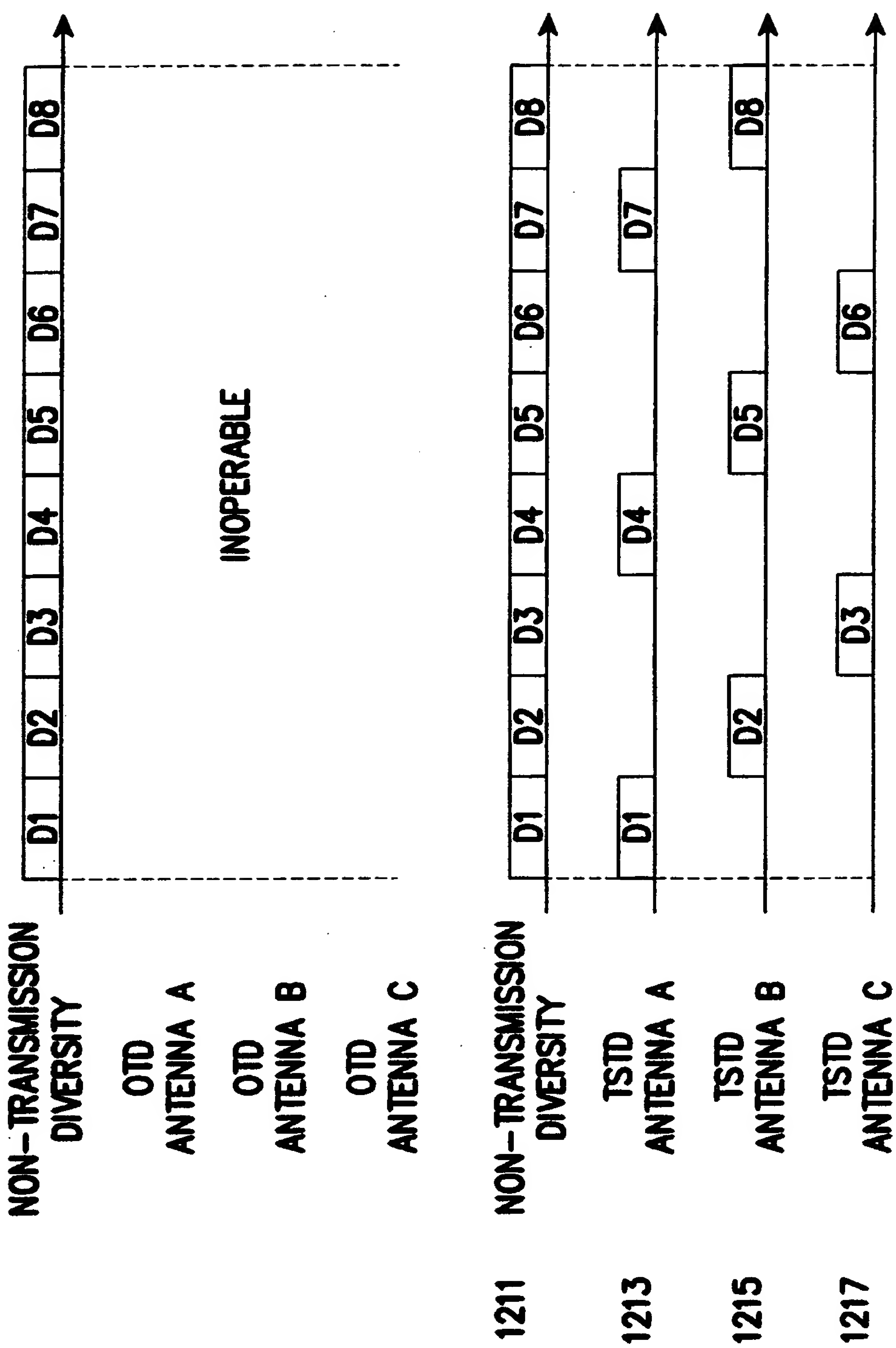
NON-TRANSMISSION DIVERSITY
OTD ANTENNA A
OTD ANTENNA B
OTD ANTENNA C
D1
D2
D3
D4
D5
D6
D7
D8
INOPERABLE
1211 NON-TRANSMISSION DIVERSITY
1213 TSTD ANTENNA A
1215 TSTD ANTENNA B
1217 TSTD ANTENNA C
D1
D2
D3
D4
D5
D6
D7
D8
D1
D4
D7
D2
D5
D8
D3
D6

FIG. 12

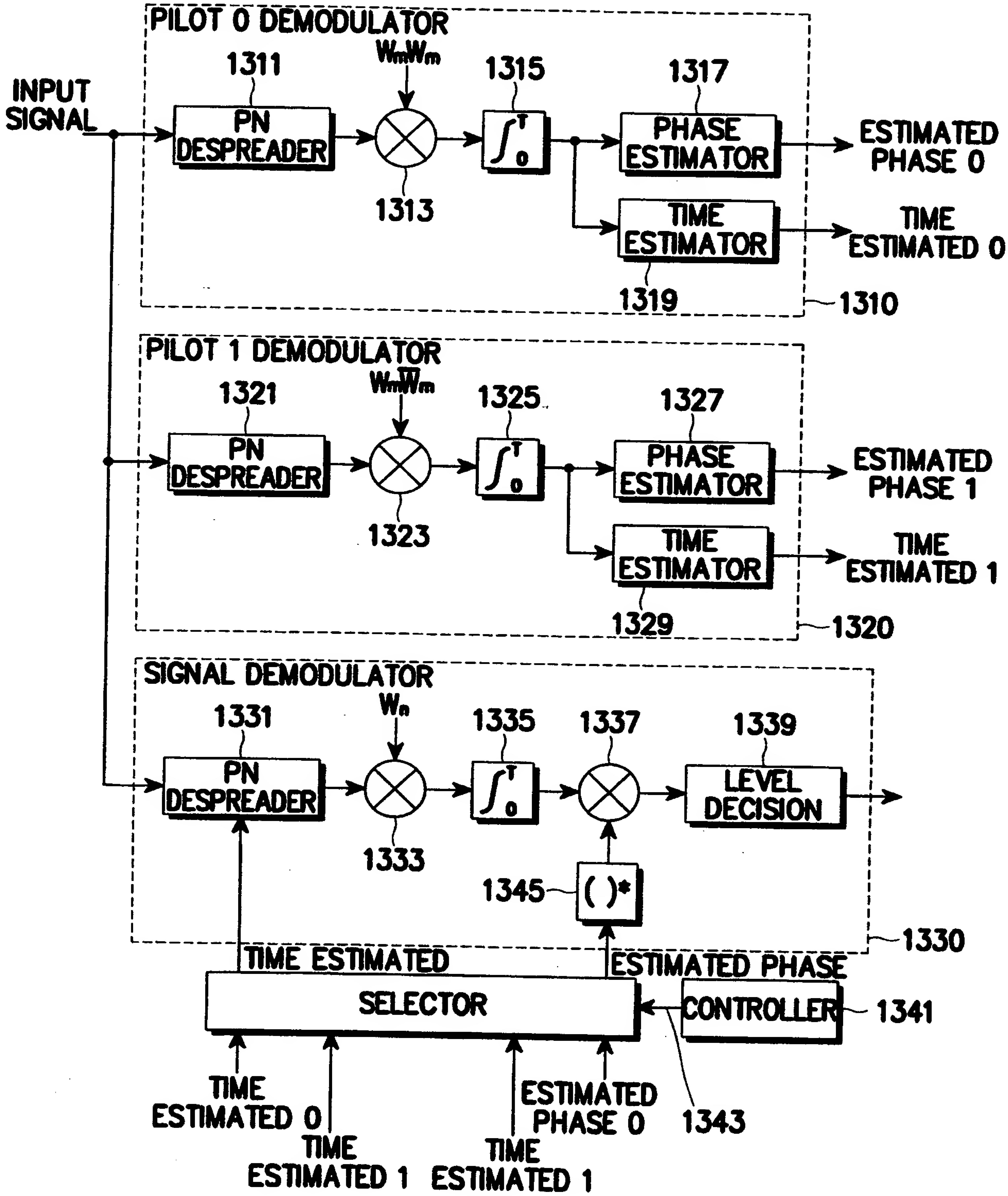
PILOT 0 DEMODULATOR
INPUT SIGNAL
1311
PN DESPREADER
WmWm
1313
1315
1317
PHASE ESTIMATOR
ESTIMATED PHASE 0
TIME ESTIMATOR
TIME ESTIMATED 0
1319
1310
PILOT 1 DEMODULATOR
1321
PN DESPREADER
WmWm
1323
1325
1327
PHASE ESTIMATOR
ESTIMATED PHASE 1
TIME ESTIMATOR
TIME ESTIMATED 1
1329
1320
SIGNAL DEMODULATOR
1331
PN DESPREADER
Wn
1333
1335
1337
1339
LEVEL DECISION
1345
( )*
1330
TIME ESTIMATED
ESTIMATED PHASE
SELECTOR
CONTROLLER
1341
TIME ESTIMATED 0
TIME ESTIMATED 1
TIME ESTIMATED 1
ESTIMATED PHASE 0
1343

FIG. 13

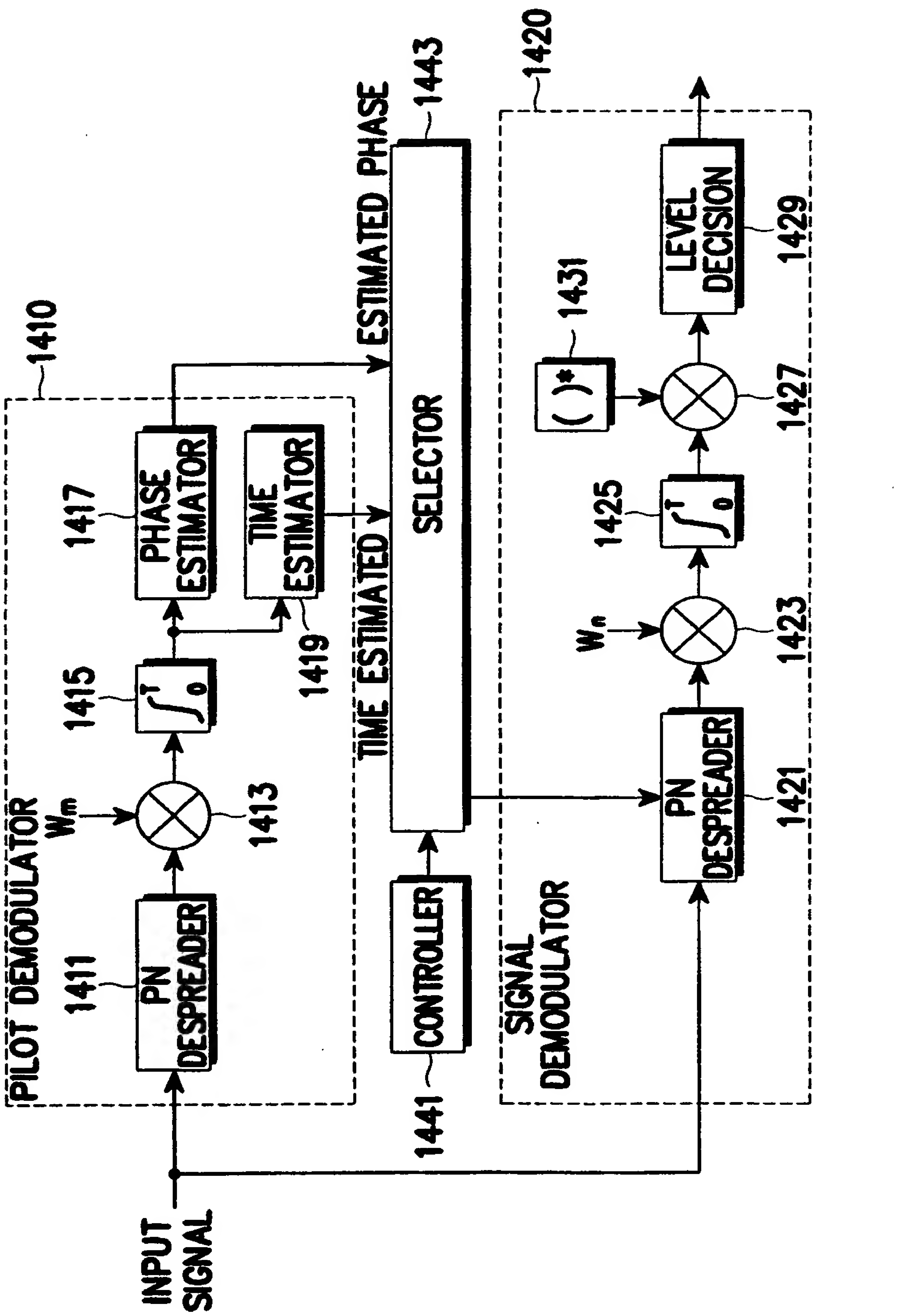
INPUT SIGNAL
PILOT DEMODULATOR
1410
1411
PN DESPREADER
W_m
1413
1415
1417
PHASE ESTIMATOR
TIME ESTIMATOR
1419
ESTIMATED PHASE
TIME ESTIMATED
1443
SELECTOR
CONTROLLER
1441
1420
SIGNAL DEMODULATOR
PN DESPREADER
1421
W_n
1423
1425
( )*
1431
1427
LEVEL DECISION
1429

FIG. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 99/00083

A. CLASSIFICATION OF SUBJECT MATTER

IPC[6]: H 04 B 7/04, 1/69

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC[6]: H 04 B 7/02, 7/04, 7/06, 1/69, 7/216

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC, WPI, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 744 841 A2 (SONY) 27 November 1996 (27.11.96), fig. 8,10; page 5, line 47 - page 6, line 9; page 7, lines 3-40.	1,5,9,11,13,17
A	US 5 652 764 A (KANZAKI) 29 July 1997 (29.07.97), fig. 1,2,8; column 3, line 63 - column 4, line 31; column 6, lines 4-31.	1,5,9,11,13,17

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:

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„E" earlier application or patent but published on or after the international filing date

„L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

„O" document referring to an oral disclosure, use, exhibition or other means

„P" document published prior to the international filing date but later than the priority date claimed

„T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

„X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

„Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

„&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 May 1999 (10.05.99)	04 June 1999 (04.06.99)

Name and mailing adress of the ISA/AT	Authorized officer
Austrian Patent Office Kohlmarkt 8-10; A-1014 Vienna Facsimile No. 1/53424/535	Dröscher Telephone No. 1/53424/320

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/KR 99/00083

Im Recherchenbericht angeführtes Patentdokument / Patent document cited in search report / Document de brevet cité dans le rapport de recherche		Datum der Veröffentlichung / Publication date / Date de publication	Mitglied(er) der Patentfamilie / Patent family member(s) / Membre(s) de la famille de brevets		Datum der Veröffentlichung / Publication date / Date de publication
EP A2	744841	27-11-1996	CN A	1140365	15-01-1997
			JP A2	8321785	03-12-1996
			US A	5787122	28-07-1998
US A	5652764	29-07-1997	CN A	1138252	18-12-1996
			GB A0	9600926	20-03-1996
			GB A1	2297224	24-07-1996
			GB B2	2297224	24-03-1999
			JP A2	8195703	30-07-1996

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